Original Article

Is Exploratory Laparoscopy the Optimal Surgical Strategy for Small Bowel Obstruction? A Single-Center Retrospective Cohort Study With Propensity Score-Matched Analysis

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Abstract

Introduction: No consensus exists on the optimal surgical strategy for small bowel obstruction (SBO). Therefore, we assessed the feasibility of laparoscopic surgery (LS) for SBO by comparing LS and open surgery (OS) outcomes.

Methods: We retrospectively analyzed 303 patients who underwent surgery for SBO. The characteristics of 233 patients who underwent exploratory LS, including 43 who underwent open conversion surgery (OCS) and 70 who underwent OS, were propensity score-matched to compare surgical outcomes. Risk factors and a predictive model for OCS were also investigated.

Results: After matching, patients who underwent LS had smaller hemorrhage volumes, fewer severe postoperative complications, and shorter postoperative hospital stays than those who underwent OS. Furthermore, the recurrence rates were comparable. The surgical outcomes of patients who underwent OCS were generally inferior to those of patients who completed LS and were almost equivalent to those of patients who underwent OS. A history of abdominal surgery, serum albumin level ≤3.8 g/dL, platelet count $\leq 15\times10^{4}/\mu L$, and neutrophil-to-lymphocyte ratio ≥6.7 were identified as independent risk factors for OCS. The OCS risk was significantly higher when the predictive model for conversion to OS was derived from risk factors scoring ≥10.

Conclusion: Overall, LS for SBO yield better outcomes than OS. Even in patients with a high predicted risk of conversion to OS, exploratory laparoscopy should be the primary surgical procedure for treating SBO.

Keywords: conversion to open surgery, laparoscopic surgery, predictive model, propensity-score matching, small bowel obstruction

1 Introduction

Small bowel obstruction (SBO) is a common abdominal emergency that requires prompt and appropriate intervention because of potentially severe complications if mismanaged.[1] Although open surgery (OS) has traditionally been performed for patients with SBO with bowel ischemia or unsuccessful conservative therapy, laparoscopic surgery (LS) has emerged as an alternative to reduce surgical invasiveness, prevent postoperative intra-abdominal adhesions, and decrease the incidence of incisional hernia formation.[2–8] However, several studies have suggested that LS for SBO may result in additional intraoperative organ injury and may not effectively prevent recurrent bowel obstruction. Therefore, the evaluation of LS for SBO has not yielded definitive conclusions,[9,10] and no consensus exists regarding the optimal surgical strategy for SBO.[5]

We aimed to retrospectively evaluate the feasibility of LS for SBO by comparing patient characteristics and surgical outcomes of LS and OS using propensity score-matched (PSM) analyses. Furthermore, preoperative risk factors for open conversion during LS were evaluated, and a predictive model was constructed.

2 Methods

2.1 Surgical Indications and Techniques

Between January 2010 and October 2013, patients with SBO at our hospital were treated with OS; since 2014, LS has been the primary treatment choice for patients with stable hemodynamic status. Emergency surgery was performed on patients with strangulated bowel obstruction and suspected bowel ischemia. Conversely, in patients with adhesive bowel obstruction at obvious site, bowel decompression was performed as preoperative preparation for elective surgery; if successful, conservative therapy was continued. Bowel decompression was performed first in some cases of strangulated bowel obstruction without evidence of bowel ischemia. Since 2014, OS has been indicated for patients with an unstable preoperative hemodynamic status.

For LS, a 12-mm port for the camera (5-mm flexible laparoscope) was initially inserted away from the site of obstruction and previous incisional scars, using an open technique to assess whether the surgical field could be visualized. CO_2 insufflation was maintained at 10 mmHg. If the patient was operable, two or three additional 5-mm ports were inserted, and the identification and release of the obstruction were continued laparoscopically; if bowel resection or assessment of bowel blood flow was required, an additional small incision was made to insert the S size of an Alexis® O Wound Protector/Retractor (Applied Medical, CA, USA). However, if the surgeon struggled to identify or release the obstruction, if the surgical field was poorly visible, or if organ injuries occurred requiring repair under direct vision, the procedure was converted to OS. Although LS was attended by surgeons with more than 3 years of experience, those certified by the Japanese endoscopic surgical skill qualification system or equivalent experience participated as operators or teaching assistants in all LS. The operator was always changed to the certified surgeon to maintain consistent LS quality before converting to OS. They would then reevaluate whether the procedure could be completed with LS. If that was impossible, the operation was converted to OS.

2.2 Study Population

Among the 367 patients diagnosed with SBO who underwent surgery at Teine Keijinkai Medical Center between January 2010 and March 2021, 64 patients were excluded for various reasons. Finally, 303 patients were enrolled (Figure 1). All patients who underwent exploratory laparoscopy between 2014 and 2021 were included in the LS group, whereas those who did not undergo exploratory laparoscopy between 2010 and 2013 were included in the OS group. Among the LS group, patients who completed LS, including those requiring a small laparotomy for bowel resection or assessment of bowel blood flow, were included in the completion of LS (CLS) group. Those in whom the obstruction could not be relieved laparoscopically and the required conversion to OS were included in the open conversion surgery (OCS) group.

The study protocol was approved by the Institutional Review Board of Teine Keijinkai Medical Center (Approval Number: 2-024163-00) and conforms to the provisions of Declaration of Helsinki. The requirement for written informed consent was waived due to the retrospective nature of the study.

2.3 Study Design

Clinical characteristics and short- and long-term outcomes were compared among the LS, OS, CLS, and OCS groups. Data were collected on the following characteristics: age, sex, body mass index (BMI), Charlson comorbidity index (CCI),[11,12] American Society of Anesthesiologists–Physical Status (ASA–PS), number of prior abdominal surgeries, history of open abdominal surgery, history of surgery for malignant disease, peritonitis, intrapelvic disease, or SBO, white blood cell (WBC) count, platelet (PLT) count, neutrophil-to-lymphocyte ratio (NLR), serum albumin (ALB) level, serum C-reactive protein (CRP) level, maximal diameter of the small bowel on initial computed tomography (CT), obstructive mechanism, preoperative long tube placement, and days from onset to surgery. Intra- and postoperative findings included LS completion, open conversion, SBO etiology (isolated band, simple adhesion [small range or sparse enteroenteral adhesion or adhesion between the small bowel and abdominal wall], or dense adhesion [extensive or severe enteroenteral adhesion or adhesion between the small bowel and abdominal wall that could not be safely dissected], bowel resection or anastomosis, use of anti-adhesive barriers, intraoperative hemorrhage volume, operation time, intraoperative organ injuries, days from surgery to first oral intake, incidence and severity of postoperative complications, postoperative hospital stay; SBO recurrence, and reoperation due to postoperative SBO recurrence. Clavien–Dindo classification (CD)[13] grade ≥2 complications within 30 days postoperatively were considered postoperative complications. SBO relapse requiring readmission was defined as SBO recurrence, and reoperation due to SBO recurrence was also assessed. Furthermore, the risk factors for OCS were investigated, and a predictive model for conversion to open surgery (COPS) was constructed.

2.4 Statistical Analysis

PSM was applied to balance preoperative factors and minimize selection biases potentially influencing postoperative outcomes. Individual propensity scores were calculated using logistic regression analysis with the following 20 covariates: age, sex (male or female), BMI, CCI, ASA-PS (1, 2, 3, or 4), number of prior abdominal surgeries (0, 1, 2, or ≥3), history of open abdominal surgery (presence or absence), history of surgery for malignant diseases (presence or absence), history of surgery for peritonitis (presence or absence), history of intrapelvic surgery (presence or absence), history of surgery for SBO (presence or absence), preoperative WBC count, preoperative PLT count, preoperative NLR, preoperative serum ALB level, preoperative serum CRP level, maximal bowie diameter in initial CT, obstructive mechanism (strangulated or adhesive), preoperative long tube placement (presence or absence), and time from onset to surgery, followed by nearest-neighbor matching performed in a 1:1 ratio with calipers set at 0.2. Standardized differences (SDs) were estimated before and after matching to evaluate the balance of covariates. We initially considered groups well balanced for the SD < .1,[14] but some covariates did not achieve this. Making the caliper width narrower caused the loss of many patients. To avoid such patient loss, we finally chose an SD of .25 instead of .1, as suggested by some statisticians.[15]

Continuous variables are presented as median values and ranges, and categorical variables are presented as numbers and percentages. The Mann–Whitney *U* test was used to analyze differences in continuous variables, whereas categorical variables were compared using Fisher’s exact test.

Multivariate logistic regression analysis was used to identify risk factors for OCS in the treatment of SBO. All variables with $P < .05$ in univariate analyses were included in multivariate analyses. The COPS score was developed by approximating the odds ratios (ORs) of variables that exhibited significant differences in the multivariate analysis. The accuracy of the COPS score was evaluated using the area under the curve (AUC) calculated from the receiver operating characteristic (ROC) curve. Statistical significance was set at $P < .05$. All statistical analyses were performed using EZR.[16]

3 Results

3.1 Comparison Between Patients Undergoing LS and Those Undergoing OS

3.1.1 Patient Characteristics

Before PSM, the LS group had a significantly lower CCI (median: 1 vs. 2, $P = .045$), lower ASA-PS ($P < .001$), lower rate of prior open abdominal surgery (median: 67.0 vs. 90.0 %, $P < .001$), higher PLT count (median: 24×10^4 vs. 20×10^4 /μL, P

= .002), and milder small bowel dilation (median: 31 vs. 34 mm, *P* = .043) than the OS group . However, no group differences were observed in other preoperative variables (Table 1).

After PSM, the SDs of all indicated preoperative variables were < .25, and the characteristics of patients in the LS and OS groups were well-matched (Table 1).

3.1.2 Short- and Long-Term Outcomes in the PSM Cohort

LS was completed in 81.5% (n = 190) of cases, whereas 18.5% (n = 43) of cases were converted to OS. After matching, the LS group had better outcomes than the OS group including lower intraoperative hemorrhage volumes (median: 5 vs. 20 g, *P* = .049), fewer postoperative complications with CD grade ≥3 (3.1 vs. 15.4 %, *P* = .030), and shorter postoperative hospital stays (median: 8 vs. 12 days, *P* = .021). Conversely, operation time, intraoperative organ injury rate, 30-day mortality, SBO recurrence rate, and reoperation due to SBO recurrence did not significantly differ between the LS and OS groups (Table

2).

The most frequent reason for conversion to surgery was a poor surgical visual field (n = 18, 41.9%) due to small bowel dilatation. Other reasons for OCS included undissectable adhesion (n = 14, 32.6%) due to dense adhesion at the obstructive site (n = 9) or isolated band which could not be safely resected (n = 5), undetectable obstructive site (n = 9, 20.9%) due to dense adhesion at the non-obstructive site (n = 2) or an obstructive site which could not be captured in the center of the visual field (n = 7), and organ injury (n = 2, 4.6%) due to forceps grasping (n = 1) or shear (n = 1; Table 3).

3.2 Comparison Between Patients With CLS and Those With OCS

3.2.1 Patient Characteristics

Before matching, patients in the OCS group were significantly more likely to have prior intrapelvic surgery (30.0 vs. 48.8 %, *P* = .021) and a lower ALB level (median: 4.1 vs 4.0 g/dL, *P* = .042) than those in the CLS group (Table 4). The *P*-values of the number of prior abdominal surgeries and obstructive mechanism were > .05 but SDs were > .25.

After PSM, history of intrapelvic surgery (SD = .001), serum ALB level (SD = .082) and obstructive mechanism (SD = .246) were balanced, but the number of prior abdominal surgeries in the CLS group remained lower than that in the OCS group (*P* = .240, SD = .468).

3.2.2 Short- and Long-term Outcomes in the PSM Cohort

After PSM, more patients with dense adhesions (2.4 vs. 26.2 %, *P* = .004), intestinal resection or anastomosis (23.8 vs. 54.8 %, *P* = .007), and postoperative complications of CD grade ≥2 (28.6 vs. 52.4 %, *P* = .045) were in the OCS group than in the CLS group (Table 5). Moreover, the operation time (median: 109 vs. 133 min, *P* < .001), days from surgery to first oral intake (median: 4 vs. 6 days, *P* = .006), and postoperative hospital stay (median: 9 vs. 16 days, *P* = .006) were significantly longer, whereas the intraoperative hemorrhage volume (median: 0 vs. 20 g, *P* < .001) was significantly smaller in the OCS group, compared with the retrospective values in the CLS group. The recurrence and reoperation rates due to SBO recurrence were similar, although the postoperative follow-up tended to be shorter in the OCS group than in the CLS group.

3.3 Comparison Between Patients With OCS and Those With OS

3.3.1 Patient Characteristics

Before matching, the OS group had significantly lower ASA-PS scores (P = .010) and a more frequent history of open abdominal surgery than the OCS group (Table 6). P-values of PLT count and obstructive mechanism were > .05 but SDs were > .25.

After PSM, ASA-PS (SD = .001), history of open abdominal surgery (SD = .001), PLT count (SD = .050), and obstructive mechanism (SD = .216) were balanced, but the history of intrapelvic surgery remained unbalanced (SD = .363).

3.3.2 Short- and Long-Term Outcomes in the Propensity

Score-Matched Cohort

Before PSM, the OCS group had more patients with complicated adhesions than the OS group, and the operation time was significantly longer in the OCS group (median: 132 vs. 105 min, P = .001; Table 7). After matching, the operation time remained significantly longer in the OCS group (median: 131 vs. 98 min, P < .001), but other short-term outcomes were generally similar. The postoperative follow-up period in the OCS group was significantly shorter than that of the OS group (median: 4.3 vs. 32.5 months, P = .030), and the SBO recurrence and reoperation rates were similar, although this is a reference finding.

3.4 Risk Factors for Conversion of LS to OS

A comparison of preoperative variables in the CLS and OCS groups revealed that patients aged ≥80 years, those who had undergone prior abdominal or intrapelvic surgery, those with adhesive bowel obstruction, or those with a PLT count $\leq 15\times10^{4}$ /μL, an NLR ≥6.7, an ALB level ≤3.8 g/dL, or a CRP level ≥1.7 mg/dL were more likely to require open conversion. Multivariate analysis of these factors revealed that a history of abdominal surgery (OR [95% confidence interval]: 3.940 [1.140–13.700], P = .031), ALB level ≤3.8 g/dL (2.920 [1.430–5.990], P = .003), PLT count ≤15×10^4/μL (2.740 [1.130–6.680], P = .026), and NLR ≥6.7 (2.610 [1.250–5.420], P = .010) were independent risk factors for OCS (Table 8).

3.5 Predictive Model for Conversion to OS

The ORs of these four factors (3.940:2.920:2.740:2.610) were calculated as 4:3:3:3, resulting in the generation of COPS scores in a scaled form (Figure 2a). The COPS score was employed to re-score the CLS and OCS groups, resulting in a mean score and standard deviation of 5.4±2.6 points in the CLS group and 8.3±3.1 points in the OCS group (Figure 2b). The COPS score was significantly higher in the OCS group than in the CLS group (P < .001). A significantly higher rate of OCS was observed in participants with a COPS score ≥10 points in the OCS groups (Figure 2b). The ROC curve for the

COPS score with a cutoff of 10 points had an AUC of 0.703 (Figure 2c). A comparison of 22 patients with a COPS score ≥10 in the OCS group and 70 patients in the OS group with PSM revealed comparable short- and long-term outcomes. However, some factors did not homogenize the patient characteristics due to the small number of cases (Tables S1, S2).

4 Discussion

The study results suggest that in patients with SBO and stable hemodynamics, LS may provide better short-term and similar long-term outcomes, compared with OS. Furthermore, our study demonstrates that the outcomes of OCS are inferior to those of CLS and almost equivalent to those of OS. Patients with a COPS score ≥10 points have a significantly higher likelihood of OCS, but surgical outcomes of OCS patients with a COPS score ≥10 points are comparable with those of OS patients. Consequently, exploratory laparoscopy as the initial surgical procedure for SBO treatment has few clinically relevant disadvantages.

LS for SBO was first reported by Bastug et al.[17] in 1991; since then, the feasibility of LS has been widely described.[2–10] However, the criteria for selecting an approach and converting it into OS vary or are not clearly stated. Moreover, several studies have defined open conversion as any instance where LS was not completed, including cases where a small laparotomy was used for small bowel resection. Other studies have classified patients undergoing open conversion as part of the OS group and compared their surgical outcomes with those of patients undergoing LS. In this study, LS was selected in all cases of SBO with stable hemodynamics, and patients who underwent exploratory laparoscopy were included in the LS group, regardless of whether a small laparotomy or open conversion was performed. The study results are reliable because we used PSM for preoperative factors, effectively minimizing biases. Therefore, this study presents the actual LS outcomes for SBO. As in previous studies, LS had more favorable short-term outcomes than OS. However, the long-term results were comparable and LS was not significantly more effective than OS in preventing SBO recurrence, as previously reported. [10] Because it is more technically difficult to dissect adhesion in LS than in OS, adhesions outside the obstructive mechanism were in our hospital not dissected as much as possible during LS for SBO to avoid secondary organ injury. We believe the recurrence rate after incomplete adhesion dissection in LS may be similar to that after OS.

The open conversion rate in this study was 18.5%. Although some reports are ambiguous regarding the criteria and definition of open conversion, the rates range from 11–63%[2–10] making our study results reasonable. This study showed that the short-term outcomes of OCS were inferior to those of patients undergoing CLS, whereas the short- and long-term outcomes of patients who underwent OCS were comparable with those of patients who underwent OS. This indicates that choosing LS has few disadvantages despite the risk of open conversion.

Nevertheless, preoperative assessment of the risk of conversion to OS is crucial, as surgical outcomes may differ significantly depending on whether the patient undergoes conversion. Most previous studies have not consistently identified the underlying causes of open conversion. Among the various potential causes, dense adhesions, bowel ischemia, and bowel injury are the most frequently cited.[6] In our study, the causes of OCS were poor visual field (42%), undissectable adhesions (33%), undetectable obstructive sites (20%), and bowel injuries (5%). A history of abdominal surgery, ALB level ≤3.8 g/dL, PLT count $\leq 15\times10^4/\mu L$, and NLR ≥6.7 were identified as preoperative risk factors for OCS. Approximately 90% of intra-abdominal adhesions result from previous abdominal surgeries, and their extent and strength of are thought to depend on the magnitude of the previous surgery.[18,19] Intra-abdominal inflammatory disease and radiation therapy have also been identified as potential causes of intra-abdominal adhesions. However, intra-abdominal inflammatory disease with extensive inflammation is more likely to be treated for peritonitis and is not included in the non-abdominal surgery group. Furthermore, no patients in this study had undergone radiotherapy. This is consistent with a history of abdominal surgery being an independent risk factor for OCS. Furthermore, a low ALB level, low PLT count, and high NLR suggest a highly inflammatory state,[20–22] such as bowel ischemia[23] or ineffective bowel decompression[24] in patients with SBO. A poor surgical field was strongly associated with bowel dilatation (Table 3). It is also common clinical experience that effective bowel decompression cannot be achieved with a long tube in cases of undissectable (hard and complicated) adhesions. Therefore, we believe that a poor visual field and undissectable adhesion which are significant causes of open conversion are associated with ineffective bowel decompression, resulting in low ALB levels, low PLT counts, and high NLRs.

The COPS score based on our results, represents a novel risk model for OCS of SBO. The AUC was 0.703 when the cutoff value of the COPS score was 10 points, indicating moderate accuracy in predicting conversion to OS. Although a higher ratio of gastrointestinal tract volume to the intra-abdominal cavity volume during CO_2 insufflation is expected to result in a poor visual field, which is the most common cause of conversion to OS, it is currently challenging to accurately assess this ratio preoperatively. This fact may explain why the AUC was not very high. However, this risk model can be used by surgeons to identify patients preoperatively at an elevated risk of OCS, statistically explain the high risk of OCS, and interpret poor surgical outcomes compared to those of CLS in patients with SBO. Therefore, while the COPS score provides a useful preoperative risk stratification, it should be integrated with the intraoperative assessment by the surgical team, as it does not necessarily reflect intraoperative factors such as surgical field visibility and tissue quality.

This study has some limitations. First, it was a single-center, retrospective study. Although PSM minimized case selection bias, it could not adjust for unobservable or unquantifiable factors. A randomized controlled trial (RCT) comparing the outcomes of LS and OS for SBO showed significantly shorter postoperative hospital stays and fewer postoperative complications in the laparoscopic group than in the OS group.[25] However, the results cannot be generalized to all patients with SBO because only patients with a high suspicion of SBO caused by a single band were included in their study. Additionally, accurately diagnosing the cause of bowel obstruction using preoperative imaging is not always easy. To establish robust evidence, an RCT should be conducted in which all patients with SBO requiring surgery are divided into two groups, OS and LS, regardless of the obstructive mechanism. Nevertheless, given the growing number of reports of laparoscopic cases with favorable outcomes, conducting RCTs appears increasingly challenging.

Second, the postoperative follow-up periods were inconsistent between the two groups compared. Therefore, the long-term outcomes of this study were only informative. Few studies have compared the long-term outcomes of LS and OS for SBO. This issue could be addressed by conducting an RCT. Finally, the surgical timing differed between the OS and LS groups. Evidence supporting the concept of enhanced recovery after surgery continues to accumulate, and the timing of oral intake initiation or hospital discharge may be earlier than previously thought.

Although the short-term outcomes of patients undergoing OCS are inferior to those of patients undergoing CLS, and the risk of open conversion is significantly higher for patients with a COPS score ≥10 points, which is defined based on the patient’s history of abdominal surgery, ALB level, PLT count, and NLR, the short-term outcomes after OCS are comparable with those after OS. Therefore, we believe that initiating laparoscopy in all patients with SBO who have stable hemodynamics has few disadvantages in determining the feasibility of LS.

Author contributions

Conceptualization, Data curation, and Formal analysis: S.F., K.K., and Y.S.; Investigation: S.F. and Y.S.; Methodology: S.F., K.K., Y.S., T.Y., and M.T.; Software: S.F.; Supervision, Validation, and Visualization: Y.K., Y.A., F.N., and S.H.; Writing – original draft preparation: S.F.; Writing – review & editing: S.F., K.K., Y.S., T.Y., M.T., Y.K., Y.A., F.N., and S.H. All authors agree with the content of the manuscript.

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Data Availability Statement

The data supporting this study’s findings are available upon request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Conflict of Interest Statement

The authors declare no conflicts of interest for this article.

Ethics Approval Statement

This study was approved by the Institutional Review Board of Teine Keijinkai Medical Center (Approval Number: 2-024163-00). All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions.

Patient Consent Statement

The requirement for written informed consent was waived because of the retrospective nature of this study.

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Figure Legends

FIGURE 1. Patient population flowchart. Between January 2010 and March 2021, 367 patients with small bowel obstruction (SBO) underwent surgery at Teine Keijinkai Medical Center. We excluded 64 patients with SBO for various reasons (24 with open surgery due to unstable hemodynamics, 13 with incarcerated hernias, 10 with foreign bodies, eight with disseminated malignancies or solid tumors, seven with aged ≤20 years, and two with inflammatory bowel disease). Finally, 303 patients were included in this study. Propensity score-matching was performed to identify 65 patients (open surgery [OS] group vs. laparoscopic surgery [LS] group), 42 patients (completion of LS [CLS] group vs. open conversion surgery [OCS] group), and 28 patients (OS group vs. OCS group) with minimal background bias for further comparisons.

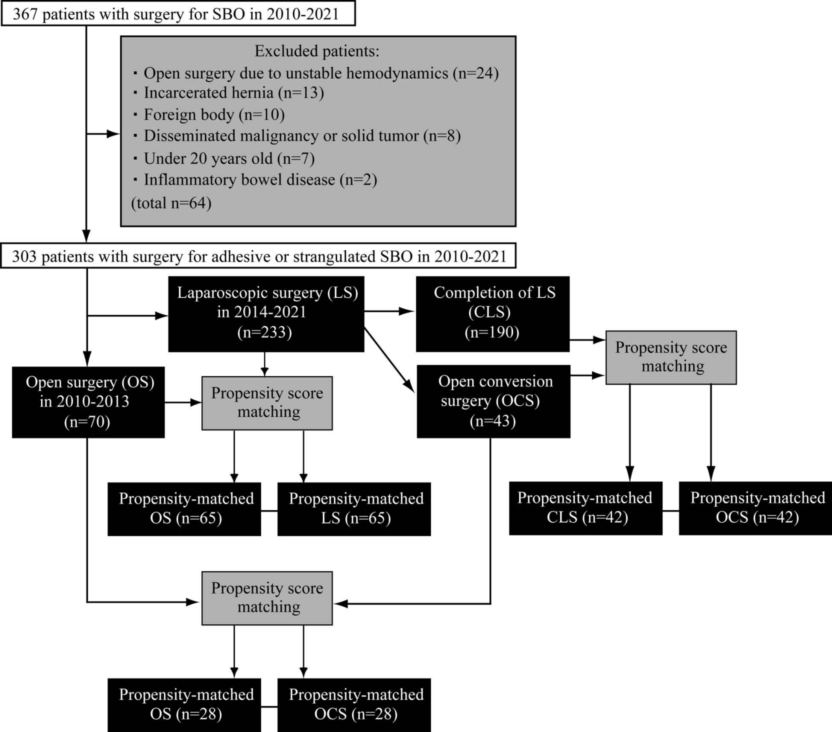
FIGURE 2. A predictive model for conversion to open surgery. a) The conversion to open surgery (COPS) score, consisting of

a history of abdominal surgery, serum albumin (ALB) level ≤3.8 g/dL, platelet (PLT) count ≤15×10^4/μL, and neutrophil-to-lymphocyte ratio (NLR) ≥6.7. b) Assessment of the risk of conversion to open surgery (OS) using the COPS score. The COPS score is significantly higher in the open conversion surgery (OCS) group than in the completion of laparoscopic surgery (CLS) group. A COPS score ≥10 points is a significant predictor of conversion to OS. Blue bars, CLS group; red bars, OCS group. $^{*}P < .05$, Fisher's exact test, $^{**}P < .001$, Mann–Whitney *U* test. StD, standard deviation. c) Receiver operating characteristic curve for the COPS score. The cutoff score is 10 points, with an area under the curve (AUC) of 0.703.

Supporting Information

SUPPLEMENTARY TABLE 1. Results of the univariate analyses of patient characteristics in the COPS ≥10 open conversion and open surgery groups.

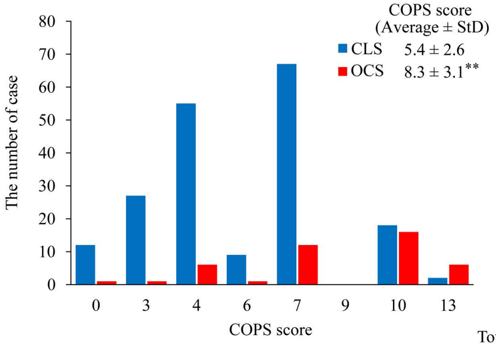
SUPPLEMENTARY TABLE 2. Comparison of short- and long-term outcomes in the COPS ≥10 open conversion and open surgery groups.


367 patients with surgery for SBO in 2010-2021
Excluded patients:
· Open surgery due to unstable hemodynamics (n=24)
· Incarcerated hernia (n=13)
· Foreign body (n=10)
· Disseminated malignancy or solid tumor (n=8)
· Under 20 years old (n=7)
· Inflammatory bowel disease (n=2)
(total n=64)
303 patients with surgery for adhesive or strangulated SBO in 2010-2021
Laparoscopic surgery (LS) in 2014-2021 (n=233)
Completion of LS (CLS) (n=190)
Open surgery (OS) in 2010-2013 (n=70)
Propensity score matching
Open conversion surgery (OCS) (n=43)
Propensity score matching
Propensity-matched OS (n=65)
Propensity-matched LS (n=65)
Propensity-matched CLS (n=42)
Propensity-matched OCS (n=42)
Propensity score matching
Propensity-matched OS (n=28)
Propensity-matched OCS (n=28)

a)

Variables	Points			
History of abdominal surgeries	Present	4	Absent	0
Serum ALB levels (g/dL)	≤ 3.8	3	> 3.8	0
PLT counts ($\times 10^4/\mu L$)	≤ 15	3	> 15	0
NLR	≥ 6.7	3	< 6.7	0

b)



	0	3	4	6	7	9	10	13	Total
CLS	12	27	55	9	67	0	18	2	190
OCS	1	1	6	1	12	0	16	6	43
Open conversion rate (%)	7.7	3.6	9.8	10.0	15.2	0	47.1*	75.0*	18.5

c)

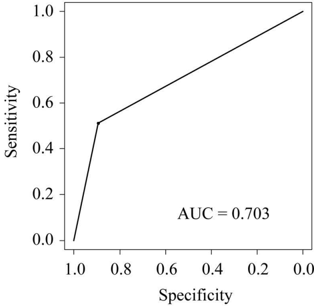


TABLE 1. Results of the univariate analyses of patient characteristics in the laparoscopic and open surgery groups

Variable	Unmatched				Propensity score-matched			
	Group LS n = 233	**Group OS n = 70**	***P*-value**	**SD**	**Group LS n = 65**	**Group OS n = 65**	***P*-value**	**SD**
Age (years)	74 [21–96]	74 [32–96]	.424*	.161	78 [23–93]	74 [32–96]	.599*	.087
Sex, Male/Female	103 / 130	37 / 33	.220**	.174	30 / 35	33 / 32	.726**	.092
BMI (kg/m^2)	20.2 [13.2–36.6]	19.8 [14.8–28.9]	.548*	.085	20.8 [14.2–36.6]	20.0 [14.8–28.9]	.395*	.166
Charlson comorbidity index	1 [0–6]	2 [0–5]	.045*	.258	2 [0–5]	2 [0–5]	.699*	.051
ASA-PS			<.001**	.490			.450**	.231
1	67 (28.8)	14 (20.0)			12 (18.5)	14 (21.5)		
2	147 (63.1)	38 (54.3)			42 (64.6)	35 (53.9)		
3	19 (8.1)	18 (25.7)			11 (16.9)	16 (24.6)		
4	0 (0.0)	0 (0.0)			0 (0.0)	0 (0.0)		
No. of prior abdominal surgeries			.055**	.398			.979**	.077
0	48 (20.6)	5 (7.1)			4 (6.2)	5 (7.7)		
1	121 (51.9)	42 (60.0)			40 (61.5)	38 (58.5)		
2	51 (21.9)	18 (25.8)			16 (24.6)	17 (26.1)		
≥3	13 (5.6)	5 (7.1)			5 (7.7)	5 (7.7)		
History of open abdominal surgery	156 (67.0)	63 (90.0)	<.001**	.584	59 (90.1)	58 (89.2)	>.999**	.051
History of surgery for malignant disease	100 (42.9)	31 (44.3)	.891**	.028	29 (44.6)	27 (41.5)	.860**	.062
History of surgery for peritonitis	11 (4.7)	6 (8.6)	.238**	.155	5 (7.7)	5 (7.7)	>.999**	.001
History of intrapelvic surgery	88 (37.8)	31 (44.3)	.332**	.106	27 (39.7)	28 (41.2)	>.999**	.217
History of surgery for SBO	20 (8.6)	11 (15.7)	.113**	.220	10 (14.7)	11 (16.2)	>.999**	.121
Preoperative laboratory data								
WBC count (×10^3/μL)	8.96 [2.27–22.06]	8.69 [2.12–21.02]	.252*	.138	8.82 [3.80–19.61]	8.62 [2.12–18.43]	.545*	.114
PLT count (×10^4/μL)	24.0 [0.5–58.3]	20.0 [7.5–41.0]	.002*	.422	21.9 [0.5–43.7]	20.0 [7.5–41.0]	.336*	.078
NLR	6.8 [0.7–91.0]	6.3 [0.7–31.7]	.633*	.065	6.8 [0.9–47.0]	6.3 [0.7–31.7]	.607*	.021
Serum ALB level (g/dL)	4.1 [1.8–5.7]	4.0 [1.5–5.0]	.347*	.110	4.1 [1.8–5.7]	4.0 [1.5–5.0]	.205*	.130
Serum CRP level (mg/dL)	0.42 [0.01–26.8]	0.53 [0.05–36.2]	.611*	.128	0.42 [0.01–22.0]	0.51 [0.05–36.2]	.579*	.012
Maximal bowel diameter on initial CT (mm)	31 [18–56]	34 [17–58]	.043*	.243	31 [18–52]	32 [17–58]	.324*	.191
Obstructive mechanism			.780**	.057			.715**	.096
Strangulated	140 (60.1)	44 (62.9)			43 (66.2)	40 (61.5)		
Adhesive	93 (39.9)	26 (37.1)			22 (33.8)	25 (38.5)		
Preoperative long tube placement	71 (30.5)	27 (38.6)	.244**	.171	20 (30.8)	23 (35.4)	.710***	.098
Days from onset to surgery	2 [0–34]	2 [0–25]	.304*	.040	2 [0–34]	2 [0–25]	.703*	.039

†Continuous variables are presented as median values and ranges.
‡Categorical variables are presented as numbers and percentages.
Abbreviations: LS, laparoscopic surgery; OS, open surgery; SD, standardized difference; BMI, body mass index; ASA-PS, American Society of Anesthesiologists Physical Status; No, number; SBO, small bowel obstruction; WBC, white blood cell; PLT, platelet; NLR, neutrophil-lymphocyte ratio; ALB, albumin; CRP, C-reactive protein; CT, computed tomography
*Mann–Whitney *U* test **Fisher's exact test

TABLE 2. Comparison of short- and long-term outcomes in the laparoscopic and open surgery groups

Variable	Unmatched			Propensity score-matched		
	Group LS n = 233	**Group OS n = 73**	***P*-value**	**Group LS n = 65**	**Group OS n = 65**	***P*-value**
Short-term outcomes						
Completion of LS	180 (81.5)	—		53 (81.5)	—	
combined with small laparotomy	69 (29.6)	—		19 (26.4)	—	
Conversion to open surgery	43 (18.5)	—		12 (18.5)	—	
Etiology of SBO			.050**			.148**
Isolated band	107 (45.9)	40 (54.8)		30 (46.2)	34 (52.3)	
Simple adhesion	111 (47.6)	24 (32.9)		32 (49.2)	23 (35.4)	
Dense adhesion	15 (6.5)	9 (12.3)		3 (4.6)	8 (12.3)	
Intestinal resection or anastomosis	74 (31.8)	33 (45.2)	.049**	21 (32.3)	29 (44.6)	.207**
Anti-adhesive barrier	92 (39.5)	26 (35.6)	.584**	29 (44.6)	24 (36.9)	.475**
Intraoperative hemorrhage (g)	5 [0–660]	20 [0–1214]	.001*	5 [0–450]	20 [0–1214]	.049*
Operation time (min)	102 [23–278]	110 [29–306]	.239*	117 [28–249]	103 [29–306]	.874*
Intraoperative organ injuries	31 (13.3)	11 (15.1)	.699**	12 (18.5)	10 (15.4)	.816**
Postoperative complications CD grade ≥2	56 (24.0)	31 (42.5)	.003**	17 (26.2)	26 (40.0)	.135**
Postoperative complications CD grade ≥3	16 (6.9)	14 (19.2)	.005**	2 (3.1)	10 (15.4)	.030**
Mortality	4 (1.7)	2 (2.7)	.631**	0 (0.0)	2 (3.1)	.496**
Days from surgery to first oral intake	4 [1–38]	5 [2–89]	.002*	4 [1–19]	5 [2–89]	.054*
Postoperative hospital stays (days)	8 [2–100]	13 [1–89]	<.001*	8 [3–51]	12 [1–89]	.021
Long-term outcomes						
Postoperative follow-up period (months)	21.0 [0.1–122.7]	37.2 [0.1–150.9]	.020*	27.3 [0.2–118.4]	38.7 [0.1–150.9]	.135*
Recurrence of SBO	30 (12.9)	10 (13.7)	.844**	10 (15.4)	8 (12.3)	.800**
Reoperation due to recurrence of SBO	21 (9.0)	4 (5.8)	.464**	9 (13.8)	3 (4.6)	.127**

†The postoperative complications before propensity score-matching included paralytic ileus (n = 26, grade 2; n = 3, grade 3a), aspiration pneumonia (n = 4, grade 5; n = 2, grade 4a; n = 2, grade 3a; n = 6, grade 2), urinary tract infection (n = 7, grade 2), abdominal abscess (n = 3, grade 2; n = 3, grade 3a), surgical site infection (n = 3, grade 3a; n = 3, grade 2), catheter-related blood stream infection (n = 3, grade 2), anastomotic hemorrhage (n = 3, grade 3a), anastomotic stenosis (n = 1, grade3a; n = 1, grade 2), anastomotic leakage (n = 1, grade 3a; n = 1, grade 3b), recurrence of SBO (n = 1, grade 3b, n = 1, grade 2), cardiac arrest (n = 1, grade 5), non-occlusive mesenteric ischemia (n = 1, grade 5), heart failure (n = 1, grade 4b), intestinal perforation (n = 1, grade 3b), pleural effusion (n = 1, grade 3a), laryngeal edema (n = 1, grade 3a), bacterial translocation (n = 1, grade 2), enterocolitis (n = 1, grade 2), sepsis (n = 1, grade 2), intra-abdominal hemorrhage (n = 1, grade 2) and anorexia (n = 1, grade 2).

‡Continuous variables are presented as median values and ranges.

§Categorical variables are presented as numbers and percentages.

Abbreviations: LS, laparoscopic surgery; OS, open surgery; SBO, small bowel obstruction; CD, Clavien–Dindo

*Mann–Whitney *U* test. **Fisher's exact test.

TABLE 3. The frequency of open conversion and associated factor for each reason of open conversion

Reasons for open conversion (n =43)	n (%)	associated factor
Poor surgical visual field	18 (41.9%)	Severe small bowel dilatation (n = 18)
Undissectable adhesion	14 (32.6%)	Dense adhesion at obstructive site (n = 9) Isolated band not safely resected (n = 5)
Obstruction site undetectable	9 (20.9%)	Dense adhesion at non-obstruction site (n = 2) Uncapturable obstruction site in the center of the visual field (n = 7)
Organ injury	2 (4.6%)	Forceps grasping injury (n = 1) Shear injury (n = 1)

TABLE 4. Results of the univariate analyses of patient characteristics in the completion of laparoscopic surgery and open conversion surgery groups

Variable	Unmatched				Propensity score-matched			
	Group CLS n = 190	Group OCS n = 43	***P*-value**	**SD**	Group CLS n = 42	Group OCS n = 42	***P*-value**	**SD**
Age (years)	73 [21–95]	80 [23–96]	.088*	.224	77 [54–94]	80 [23–96]	.830*	.167
Sex, Male/Female	85 / 105	18 / 25	.865**	.058	16 / 26	17 / 25	>.999**	.049
BMI (kg/m^2)	20.5 [13.2–36.6]	19.6 [13.8–29.3]	.160*	.254	20.1 [14.3–27.8]	19.7 [13.8–29.3]	.491*	.127
Charlson comorbidity index	1 [0–6]	1 [0–6]	.986*	.007	2 [0–5]	2 [0–6]	.923*	.001
ASA-PS			.833**	.094			.681*	.207
1	56 (29.5)	11 (25.6)			8 (19.1)	11 (26.2		
2	119 (62.6)	28 (65.1)			31 (73.8)	27 (64.3)		
3	15 (7.9)	4 (9.3)			3 (7.1)	4 (9.5)		
4	0 (0.0)	0 (0.0)			0 (0.0)	0 (0.0)		
No. of prior abdominal surgeries			.066**	.488			.240*	.468
0	45 (23.7)	3 (7.0)			6 (14.3)	3 (7.1)		
1	94 (49.5)	27 (62.8)			19 (45.2)	27 (64.3)		
2	40 (21.0)	11 (25.6)			13 (31.0)	11 (26.2)		
≥3	11 (5.8)	2 (4.6)			4 (9.5)	1 (2.4)		
History of open abdominal surgery	124 (65.3)	32 (74.4)	.285**	.200	32 (76.2)	31 (73.8)	>.999**	.055
History of surgery for malignant disease	81 (42.6)	19 (44.2)	.866**	.031	19 (45.2)	18 (42.9)	>.999**	.048
History of surgery for peritonitis	9 (4.7)	2 (4.6)	>.999**	.004	3 (7.1)	2 (4.8)	>.999**	.101
History of intrapelvic surgery	57 (30.0)	21 (48.8)	.021**	.244	20 (47.6)	20 (47.6)	>.999**	.001
History of surgery for SBO	15 (7.9)	5 (11.6)	.383**	.126	6 (14.3)	4 (9.5)	.738**	.147
Preoperative laboratory data								
WBC count (×10^3/μL)	8.96 [2.27–22.06]	10.10 [3.80–17.61]	.343*	.099	8.63 [3.39–22.06]	9.90 [3.80–17.61]	.336*	.039
PLT count (×10^4/μL)	24.0 [5.5–53.3]	24.0 [0.5–58.3]	.959*	.041	24.0 [5.5–51.5]	24.0 [0.5–58.3]	.809*	.021
NLR	6.8 [0.7–91.0]	7.0 [1.5–45.2]	.241*	.022	6.8 [0.7–47.0]	6.3 [1.5–45.2]	.441*	.016
Serum ALB level (g/dL)	4.1 [1.8–5.7]	4.0 [2.1–5.1]	.042*	.328	4.1 [1.9–4.8]	4.0 [2.1–5.1]	.604*	.082
Serum CRP level (mg/dL)	0.42 [0.01–26.8]	0.72 [0.01–14.7]	.271*	.156	0.53 [0.01–22.0]	0.83 [0.01–14.7]	.771*	.081
Maximal bowel diameter on initial CT (mm)	31 [19–56]	31 [18–54]	.746*	.054	34 [22–56]	31 [18–54]	.168*	.220
Obstructive mechanism			.057**	.399			.372**	.246
Strangulated	120 (63.2)	20 (46.5)			14 (33.3)	19 (45.2)		
Adhesive	70 (36.8)	23 (53.5)			28 (66.7)	23 (54.8)		
Preoperative long tube placement	58 (30.5)	13 (30.2)	>.999**	.006	17 (40.5)	13 (31.0)	.495**	.200
Days from onset to surgery	2 [0–31]	2 [0–34]	.598*	.046	3 [0–30]	2 [0–34]	.360*	.122

†Continuous variables are presented as median values and ranges.
‡Categorical variables are presented as numbers and percentages
Abbreviations: CLS, completion of laparoscopic surgery; OCS, open conversion surgery; SD, standardized difference; BMI, body mass index; ASA-PS, American Society of Anesthesiologists Physical Status; No, number; SBO, small bowel obstruction; WBC, white blood cell; PLT, platelet; NLR, neutrophil-lymphocyte ratio; ALB, albumin; CRP, C-reactive protein; CT, computed tomography
*Mann–Whitney *U* test **Fisher's exact test

TABLE 5. Comparison of short- and long-term outcomes in the completion of laparoscopic surgery and open conversion surgery groups

Variable	Unmatched			Propensity-matched		
	Group CLS n = 190	**Group OCS n = 43**	***P*-value**	**Group CLS n = 42**	**Group OCS n = 42**	***P*-value**
Short-term outcomes						
Etiology of SBO			<.001			.004**
Isolated band	95 (50.0)	12 (27.9)		12 (28.6)	12 (28.6)	
Simple adhesion	91 (47.9)	20 (46.5)		29 (69.0)	19 (45.2)	
Dense adhesion	4 (2.1)	11 (25.6)		1 (2.4)	11 (26.2)	
Intestinal resection or anastomosis	50 (26.3)	24 (55.8)	<.001**	10 (23.8)	23 (54.8)	.007**
Anti-adhesive barrier	71 (37.4)	21 (48.8)	.172**	19 (45.2)	20 (47.6)	>.999**
Intraoperative hemorrhage (g)	1 [0–660]	20 [0–500]	<.001*	0 [0–300]	20 [0–500]	<.001*
Operation time (min)	93 [23–221]	131 [72–278]	<.001*	109 [35–197]	133 [72–278]	<.001*
Intraoperative organ injuries	18 (9.5)	13 (30.2)	<.001**	7 (16.7)	13 (31.0)	.200**
Postoperative complications CD grade ≥2	33 (17.4)	23 (53.5)	<.001**	12 (28.6)	22 (52.4)	.045**
Postoperative complications CD grade ≥3	7 (3.7)	9 (20.9)	<.001**	3 (7.1)	9 (21.4)	.116**
Mortality	1 (0.5)	3 (7.0)	.021**	1 (2.4)	3 (7.1)	.616**
Days from surgery to first oral intake	3 [1–36]	6 [2–38]	<.001*	4 [1–36]	6 [2–38]	.008*
Postoperative hospital stays (days)	7 [2–51]	16 [3–100]	<.001*	9 [3–51]	16 [3–100]	.006*
Long-term outcomes						
Postoperative follow-up period (months)	24.3 [0.1–122.8]	5.3 [0.1–111.8]	.064*	26.2 [0.2–107.3]	6.4 [0.1–111.8]	.081*
Recurrence	26 (13.7)	4 (9.3)	.615**	6 (14.3)	4 (9.5)	.738**
Reoperation due to recurrence	18 (9.5)	3 (7.0)	.773**	3 (4.6)	3 (4.6)	>.999**

†The postoperative complications before propensity score matching included paralytic ileus (n = 19, grade 2; n = 3, grade 3a), aspiration pneumonia (n = 3, grade 5; n = 2, grade 4a; n = 2, grade 3a; n = 1, grade 2), surgical site infection (n = 1, grade 3a; n = 3, grade 2), urinary tract infection (n = 4, grade 2), anastomotic hemorrhage (n = 3, grade 3a), abdominal abscess (n = 2, grade 3a), catheter related blood stream infection (n = 2, grade 2), cardiac arrest (n = 1, grade 5), non-occlusive mesenteric ischemia (n = 1, grade 5), anastomotic leakage (n = 1, grade 3b), intestinal perforation (n = 1, grade 3b), anastomotic stenosis (n = 1, grade3a), pleural effusion (n = 1, grade 3a), laryngeal edema (n = 1, grade 3a), enterocolitis (n = 1, grade 2), sepsis (n = 1, grade 2) and anorexia (n = 1, grade 2).
‡Continuous variables are presented as median values and ranges.
§Categorical variables are presented as numbers and percentages.
Abbreviations: SBO, small bowel obstruction; CD, Clavien–Dindo
*Mann–Whitney *U* test. **Fisher's exact test.

TABLE 6. Results of the univariate analyses of patient characteristics in the open conversion and open surgery groups

Variable	Unmatched				Propensity score-matched			
	Group OCS n = 43	Group OS n = 70	*P*-value	SD	Group OCS n = 28	Group OS n = 28	*P*-value	SD
Age (years)	80 [23–96]	74 [32–96]	.496*	.034	77 [23–96]	79 [32–96]	.688*	.108
Sex, Male/Female	18 / 25	37 / 33	.333**	.222	13 / 15	16 / 12	.593**	.145
BMI (kg/m^2)	19.6 [13.8–29.3]	19.8 [14.8–28.9]	.529*	.135	19.7 [13.8–28.3]	19.8 [15.6–26.6]	.851*	.055
Charlson comorbidity index	1 [0–6]	2 [0–5]	.184*	.242	2 [0–2]	1 [0–5]	.979**	.064
ASA-PS			.010**	.443			>.999**	.001
1	11 (25.6)	14 (20.0)			7 (25.0)	7 (25.0)		
2	28 (65.1)	38 (54.3)			18 (64.3)	18 (64.3)		
3	4 (9.3)	18 (25.7)			3 (10.7)	3 (10.7)		
4	0 (0.0)	0 (0.0)			0 (0.0)	0 (0.0)		
No. of prior abdominal surgeries			.985**	.109			>.999**	.248
0	3 (7.0)	5 (7.1)			2 (6.9)	3 (10.3)		
1	27 (62.8)	42 (60.0)			16 (55.2)	15 (51.7)		
2	11 (25.6)	18 (25.8)			9 (31.0)	8 (27.6)		
≥3	2 (4.6)	5 (7.1)			2 (6.9)	3 (10.3)		
History of open abdominal surgery	32 (74.4)	63 (90.0)	.010**	.522	24 (85.7)	24 (85.7)	>.999**	.001
History of surgery for malignant disease	19 (44.2)	31 (44.3)	>.999**	.002	13 (46.4)	12 (42.9)	>.999**	.072
History of surgery for peritonitis	2 (4.6)	6 (8.6)	.708**	.158	3 (10.7)	2 (6.9)	>.999**	.125
History of intrapelvic surgery	21 (48.8)	31 (44.3)	>.999**	.091	12 (42.9)	17 (60.7)	.285**	.363
History of surgery for SBO	5 (11.6)	11 (15.7)	.593**	.119	5 (17.9)	6 (21.4)	>.999**	.090
Preoperative laboratory data								
WBC count ($\times 10^3$/μL)	10.10 [3.80–17.61]	8.69 [2.12–21.02]	.150*	.228	10.16 [3.80–17.61]	9.69 [3.99–21.02]	.987*	.092
PLT count ($\times 10^4$/μL)	24.0 [0.5–58.3]	20.0 [7.5–41.0]	.050*	.395	21.7 [0.5–42.9]	20.0 [7.5–41.0]	.646*	.050
NLR	7.0 [1.5–45.2]	6.3 [0.7–31.7]	.193*	.092	7.2 [1.5–45.2]	6.1 [1.1–31.3]	.372*	.039
Serum ALB level (g/dL)	4.0 [2.1–5.1]	4.0 [1.5–5.0]	.413*	.161	4.1 [2.5–4.7]	4.1 [1.5–5.0]	.510*	.072
Serum CRP level (mg/dL)	0.72 [0.01–14.7]	0.53 [0.05–36.2]	.590*	.028	0.39 [0.01–14.7]	0.34 [0.05–4.54]	.724*	.225
Maximal bowel diameter on initial CT (mm)	31 [18–54]	34 [17–58]	.220*	.190	31 [18–50]	31 [23–58]	.675*	.177
Obstructive mechanism			.118**	.333			.593*	.216
Strangulated	20 (46.5)	44 (62.9)			15 (53.6)	12 (42.9)		
Adhesive	23 (53.5)	26 (37.1)			13 (46.4)	16 (57.1)		
Preoperative long tube placement	13 (30.2)	27 (38.6)	.421**	.176	9 (32.1)	11 (39.3)	.781*	.149
Days from onset to surgery	2 [0–34]	2 [0–25]	.246*	.077	1 [0–34]	2 [0–25]	.291*	.053

†Continuous variables are presented as median values and ranges.
‡Categorical variables are presented as numbers and percentages.
Abbreviations: OCS, open conversion surgery; OS, open surgery; SD, standardized difference; BMI, body mass index, ASA-PS, American Society of Anesthesiologists Physical Status; No, number; SBO, small bowel obstruction; WBC, white blood cell; PLT, platelet; No, number; NLR, neutrophil-lymphocyte ratio; ALB, albumin; CRP, C-reactive protein; CT, computed tomography
*Mann–Whitney *U* test. **Fisher's exact test.

TABLE 7. Comparison of short- and long-term outcomes in the open conversion and open surgery groups

Variable	Unmatched			Propensity-matched		
	Group OCS n = 43	**Group OS n = 70**	***P*-value**	**Group OCS n = 28**	**Group OS n = 28**	***P*-value**
Short-term outcomes						
Etiology of SBO			.017**			.452**
Isolated band	12 (27.9)	38 (54.3)		8 (28.6)	10 (35.7)	
Simple adhesion	20 (46.5)	23 (32.9)		12 (42.8)	14 (50.0)	
Dense adhesion	11 (25.6)	9 (12.8)		8 (28.6)	4 (14.3)	
Intestinal resection or anastomosis	24 (55.8)	30 (42.9)	.245**	15 (53.6)	8 (28.6)	.102**
Anti-adhesive barrier	21 (48.8)	26 (37.1)	.243**	13 (46.4)	13 (46.4)	>.999**
Intraoperative hemorrhage (g)	20 [0–500]	15 [0–1214]	.544*	32 [0–500]	20 [0–450]	.403*
Operation time (min)	131 [72–278]	105 [29–306]	.001*	131 [72–278]	98 [50–229]	<.001*
Intraoperative organ injuries	13 (30.2)	11 (15.7)	.100**	10 (35.7)	5 (17.9)	.227**
Postoperative complications CD grade ≥2	23 (53.5)	30 (42.9)	.333**	16 (57.1)	13 (46.4)	.593**
Postoperative complications CD grade ≥3	9 (20.9)	14 (20.0)	>.999**	5 (17.9)	4 (14.3)	>.999**
Mortality	3 (7.0)	2 (2.9)	.367**	1 (3.6)	0 (0.0)	>.999**
Days from surgery to first oral intake	6 [2–38]	5 [2–89]	.072*	6 [3–38]	6 [2–89]	.387*
Postoperative hospital stays (days)	16 [3–100]	13 [1–89]	.118*	18 [6–100]	16 [5–89]	.407*
Long-term outcomes						
Postoperative follow-up period (months)	5.3 [0.1–111.8]	39.8 [0.1–150.9]	.002*	4.3 [0.5–102.8]	32.5 [0.3–150.9]	.030*
Recurrence	4 (9.3)	10 (14.3)	.562**	4 (14.3)	5 (17.9)	>.999**
Reoperation due to recurrence	3 (7.0)	4 (5.7)	>.999**	3 (10.7)	3 (10.7)	>.999**

†The postoperative complications before propensity score matching included paralytic ileus (n = 16, grade 2; n = 3, grade 3a), aspiration pneumonia (n = 3, grade 5; n = 2, grade 4a; n = 2, grade 3a; n = 1, grade 2), surgical site infection (n = 1, grade 3a; n = 3, grade 2, n = 1, grade 1), urinary tract infection (n = 3, grade 2), anastomotic hemorrhage (n = 3, grade 3a), abdominal abscess (n = 2, grade 3a), catheter related blood stream infection (n = 5, grade 2), cardiac arrest (n = 1, grade 5), non-occlusive mesenteric ischemia (n = 1, grade 5), anastomotic leakage (n = 1, grade 3b), intestinal perforation (n = 1, grade 3b), anastomotic stenosis (n = 1, grade3a), pleural effusion (n = 1, grade 3a), laryngeal edema (n = 1, grade 3a), enterocolitis (n = 1, grade 2), sepsis (n = 1, grade 2) and anorexia (n = 1, grade 2).

‡Continuous variables are presented as median values and ranges.

§Categorical variables are presented as numbers and percentages.

Abbreviations: OCS, open conversion surgery; OS, open surgery; SBO, small bowel obstruction; CD, Clavien–Dindo

*Mann–Whitney *U* test. **Fisher's exact test.

TABLE 8. Results of the univariate and multivariate analyses of risk factors for open conversion

Variable	n	Univariate: Group CLS n = 190	Univariate: Group OCS n = 43	Univariate: *P*-value	Multivariate: Odds ratio	Multivariate: 95% CI	Multivariate: *P*-value
Age (years)				.008			
≤79	155	134	21		1		
≥80	78	56	22		1.670	0.790–3.540	.179
Sex				.732			
Male	103	85	18				
Female	130	105	25				
BMI (kg/m^2)				.163			
≤20	115	89	26				
>20	118	101	17				
Charlson comorbidity index				.866			
≤1	117	86	21				
≥2	126	104	22				
ASA-PS				.611			
Class 1	67	56	11				
Class ≥2	166	134	32				
History of abdominal surgery				.012			
Absent	50	47	3		1		
Present	183	143	40		3.940	1.140–13.700	.031
History of open abdominal surgery				.285			
Absent	77	66	11				
Present	156	124	32				
History of surgery for malignant disease				.866			
Absent	133	109	24				
Present	100	81	19				
History of surgery for peritonitis				>.999			
Absent	222	181	41				
Present	11	9	2				
History of intrapelvic surgery				.021			
Absent	155	133	22		1		
Present	78	57	21		1.830	0.853–3.930	.121
History of surgery for SBO				.433			
Absent	213	175	38				
Present	20	15	5				
WBC count ($\times 10^3/\mu L$)				.112			
≤10.00	139	118	21				
>10.00	94	72	22				
PLT count ($\times 10^4/\mu L$)				.024			
≤15	32	21	11		2.740	1.130–6.680	.026
>15	201	169	32		1		
NLR				.007			
<6.7	122	107	15		1		
≥6.7	111	83	28		2.610	1.250–5.420	.010
Serum ALB level (g/dL)				.024			
≤3.8	72	51	21		2.920	1.430–5.990	.003
>3.8	161	139	22		1		
Serum CRP level (mg/dL)				.022			
<1.7	164	140	24		1		
≥1.7	69	50	19		1.190	0.540–2.640	.662
Maximal bowel diameter on initial CT (mm)				.555			
<31	134	111	23				
≥31	99	79	20				
Obstructive mechanism				.046			
Strangulated	107	87	20		1.430	0.671–3.040	.355
Adhesive	116	93	23		1		
Preoperative long tube placement				.970			
No	166	136	30				
Yes	71	58	13				
Days from onset to surgery				.325			
≤6	176	149	35				
≥7	57	49	8				

†Fisher’s exact test was used for the univariate analysis.
‡Logistic regression analysis was used for the multivariate analysis.
Abbreviations: CLS, completion of laparoscopic surgery; OCS, open conversion surgery; CI, confidence interval; BMI, body mass index; ASA-PS, American Society of Anesthesiologists Physical Status; SBO, small bowel obstruction; WBC, white blood cell; PLT, platelet; NLR, neutrophil-lymphocyte ratio; ALB, albumin; CRP, C-reactive protein; CT, computed tomography.